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# SHELTERBELT TREE and SHRUB SPECIES Under Dryland Culture in the Central Great Plains

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# SHELTERBELT TREE and SHRUB SPECIES Under Dryland Culture in the Central Great Plains<sup>1</sup>

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The central Great Plains as defined in this report is an area naturally devoid of trees except along the principal waterways and upon some few broken, rocky foothills near the mountains in the western and northern parts of the area. Some of the early efforts to grow trees in the area were probably influenced by forestry practices from other parts of the United States. The object of these early plantings was to grow timber for fenceposts, poles, and fuel and to produce trees to break the wind. Those plantings were not very successful. With a changing economy and accumulated observation and experience it became evident that the greatest value of tree and shrub plantings in the area was for shelter from wind, storm, and blizzard.

The Cheyenne Horticultural Field Station was established by an act of Congress in 1928 for research on various horticultural plants, including shade, ornamental, and shelterbelt trees and shrubs. The work was to be done at the Cheyenne station and throughout the central Great Plains. The first experimental farmstead shelterbelt plantings from the Cheyenne station were made in 1932 in cooperation with certain selected ranchers and farmers.

The cooperative shelterbelts developed by the Cheyenne station staff were planted in counties of the area where other governmental agencies had made few or no plantings. Hence, most of the plantings were in southwestern South Dakota, southeastern Wyoming, eastern Colorado, and northwestern Kansas; a few plantings were in western Nebraska. The Cheyenne station tested at least one tree or shrub species of unknown adaptability at each cooperator location. Responsibility for data on certain plantings made earlier in parts of the area by the station at Mandan, N. Dak., was transferred to the Cheyenne station in 1932.

This report gives survival, growth, and killback data obtained from representative experimental shelterbelts in the central Great Plains area.

## EARLY SPECIES STUDIES

Adaptable species and methods for growing shelterbelts for the entire Great Plains region have been recommended by Johnson and

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<sup>1</sup> This report is in part from a master's thesis. Copy on file at the University of Wyoming, Laramie, Wyo.

Cobb (12),<sup>2</sup> Bates (3), and Read (19). Similar recommendations for the northern Great Plains have been made by George (6, 7, 8), Aune and coworkers (2), Ferrell (5), Hansen (9), Thompson (20), and Towle (21). Species recommendations, cultural practices, and related data pertaining to shelterbelt establishment in the central Great Plains have been set forth by the Nebraska Agricultural College (1), Edmondson (4), Hildreth (10), Johnson (11), Mathews and Clark (15), Maxwell (16), McComb (14), Nelson (17), and Preston and Brandon (18).

## MATERIALS AND METHODS

The area that this report covers is generally called the central Great Plains. It covers approximately 150,000 square miles and includes parts of South Dakota, Nebraska, Kansas, Colorado, and Wyoming (fig. 1). Generally speaking, the area is bounded by the Rocky Mountains on the west, but excludes mountainous terrain; by the White River or its approximate latitude on the north; on the east by the 99th meridian in Kansas and South Dakota and by the 100th meridian in Nebraska; and by the Arkansas River on the south. The river systems and their tributaries that drain the area include, from north to south, the south drainage of the White River, the Niobrara River, the North and South Platte Rivers, the Republican River, and the north drainage of the Arkansas River.

### Soils

Most of the shelterbelt sites that were inspected had rich or moderately rich loam soils varying from sandy and sandy loams to silt and clay loams. Generalized maps and discussion of soil types within the central Great Plains have been published (22).

### Climate

The climate of the central Great Plains is characterized by low annual rainfall, low humidity, high average wind velocity, and low winter temperatures. The general pattern at the same latitude shows less rainfall, higher winter temperatures, and lower summer temperatures in the western part of the area than in the eastern part.

Complete weather summaries for numerous stations in the area, from the year the reporting stations were established through 1938, have been published (13). Average annual rainfall lines for the central Great Plains are shown in figure 1. Later weather data are also available from the U.S. Weather Bureau (23, 24, 25, 26, 27). The warmer temperatures, the greater rainfall, and the longer growing season of the southern and eastern sections of the area do not necessarily mean that all trees and shrubs grow better in those sections.

### Cooperative Arrangements

To test species response adequately in the entire central Great Plains area, it was necessary to have shelterbelts in all the principal

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<sup>2</sup> Italic numbers in parentheses refer to Literature Cited, p. 15.



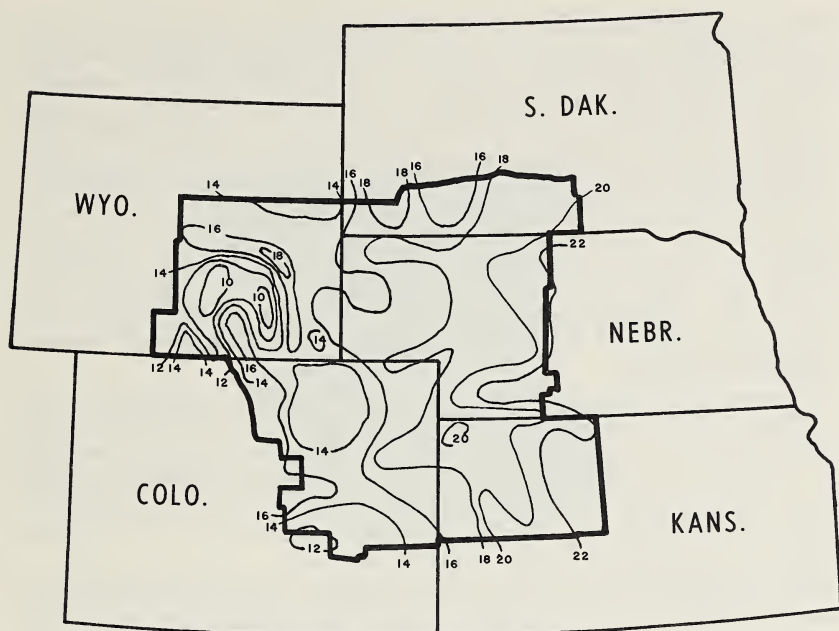


Figure 1.—The central Great Plains area, outlined by dark lines, showing the average annual rainfall, in inches, as adapted from (13).

parts of the area. This objective was accomplished by enlisting the aid of farmers and ranchers in planting cooperative shelterbelts. Plantings to shelter rural homesites predominated, but some shelterbelts were planted to protect livestock, fields, or gardens.

The cooperative arrangements were simple. The Cheyenne Horticultural Field Station furnished the nursery stock, the planting plans, and instructions for planting and maintenance. The cooperator provided the land, necessary fencing, labor, and equipment for planting and care of the trees. The cooperator also paid transportation charges on the nursery stock and signed an agreement to follow, as nearly as possible, instructions from the Cheyenne station regarding establishment and maintenance of the shelterbelt.

The original plan called for regular inspections to be made on all cooperative shelterbelts. However, that objective was not attained, in part, because resources were curtailed coincidental with the beginning of World War II. After about 15 years, during which only a few of the cooperative shelterbelts were visited by personnel from the Cheyenne station, field study was resumed and continued through the fall of 1956. Complete notes and measurements were taken on all tree and shrub species in each sample shelterbelt in order to evaluate the species.

### Sampling Methods

It is impractical to collect data on the entire population of shelterbelt trees and shrubs growing in the central Great Plains. There-

fore, the object of this phase of the shelterbelt study was to obtain data on a representative sample of the shelterbelts growing in each of the 79 counties throughout the area. The sample usually consisted of 3 to 15 dryland plantings in each county, in proportion to county size and the frequency of shelterbelt plantings. Sample shelterbelts within the area included those planted by the Mandan and the Cheyenne field stations and such other shelterbelts as were needed for a representative number of plantings within a county. Data were obtained on 482 shelterbelts from 1954 through 1956. To avoid a possible bias of personal opinion that might tend to direct the investigator to only the superior plantings within a county, the investigator contacted the county agents or Soil Conservation personnel within counties only to obtain help in locating shelterbelts planted by the two experiment stations.

In the few instances where more than enough plantings by the Cheyenne and Mandan experiment stations were available for study, all plantings were inspected and the required plantings were selected by the use of random numbers. To avoid giving too much weight to a sample having many rows of trees or shrubs over one with fewer rows, the investigator obtained data on no more than the first five rows of a species of the same age in a shelterbelt.

The procedure was to measure the Mandan and Cheyenne field station plantings within a county and then to measure enough other shelterbelts selected at random from the four quarters of the county, regardless of the planting agency, to reach the desired sample number. No planting was inspected and included in the study unless the age of the trees or shrubs was known and unless they were planted systematically, i.e., no mixing of species within the row and with uniform spacing distances both in and between rows. Measurements were made as follows:

**Survival.**—Actual counts were made where the number of trees or shrubs planted was known; where the number planted was unknown, estimates were based on either spot or complete counts.

**Height and crown spread.**—Sample trees or shrubs most characteristic of those in each row were measured.

**Killback.**—Killback was rated according to the type and amount of deadwood, and as a mean for the surviving trees or shrubs of an entire row. These ratings were later converted to a percentage basis as follows: none, 0 percent; light, 20 percent; moderate, 40 percent; heavy, 60 percent; severe, 80 percent; dead, 100 percent. The term "killback" is used instead of "winter injury," since much injury to trees and shrubs in the central Great Plains is caused by summer drought, hail, insects, and wind, as well as by winter weather conditions.

Field notes that were taken on every species in every shelterbelt that was sampled in this study are the basis for the species discussions (p. 8). The survival, growth, and killback data (p. 10) were compiled in a short time from shelterbelts of different ages rather than by successive observations of the same rows of trees or shrubs at 5 years, 14 years, and 17 to 32 years after planting.

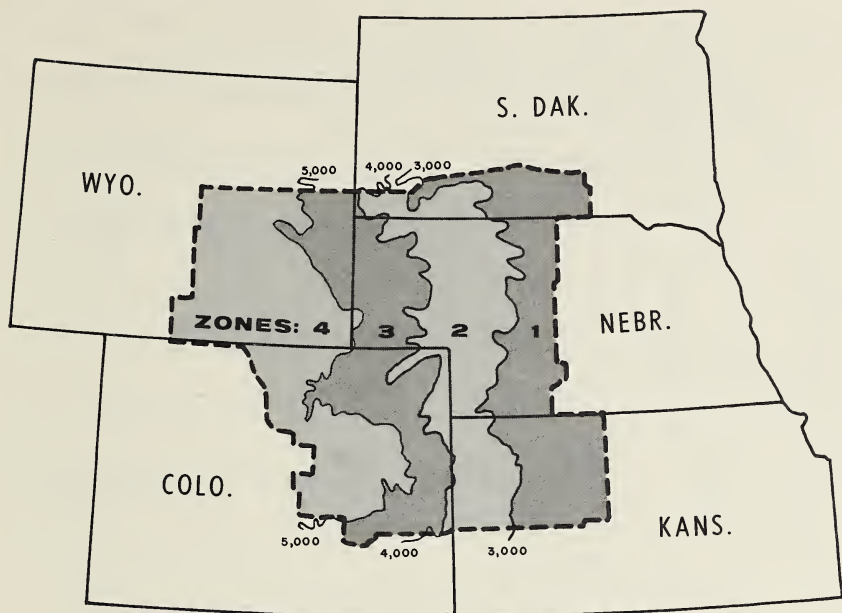


Figure 2.—The central Great Plains area, outlined by dotted lines, showing elevation contour lines (by 1000-foot intervals), which divide the area into the four altitude zones by which the shelterbelts of this study were summarized.

### Zoning the Area

Although the data for this study were collected on a county basis, statistical calculations were used to select the best method for presenting the data. Four methods of zoning—by altitude, by longitude, and by two methods of geographic division—were compared. The area was divided into four zones by each zoning method. Statistical results showed that greater differences in species response existed among the altitude zones than among the others tested; hence, the area was divided into four altitude zones for species comparisons (fig. 2). These were zone 1, below 3,000 feet; zone 2, 3,000 to 4,000 feet; zone 3, 4,000 to 5,000 feet; and zone 4, above 5,000 feet.

In this area, the higher the altitude the less the rainfall. This fact should be remembered when evaluating altitude zone comparisons, for the difference in rainfall may be as responsible for the species differences between zones as is the altitude or other limiting factors.

### RATINGS, COMPARISONS, AND ADAPTABILITY OF SPECIES

All tree and shrub species in each shelterbelt were rated at the time of inspection according to their ability to provide shelter from the elements. They were classed, on a numerical basis, as superior, intermediate, or inferior (table 1). These ratings should be used together

TABLE 1.—*Ratings of shelterbelt species, by zones, in the central Great Plains*<sup>1 2</sup>

Group and species	Zone 1				Zone 2				Zone 3				Zone 4			
	Times rated	Ratings			Times rated	Ratings			Times rated	Ratings			Times rated	Ratings		
		Superior	Inter-mediate	Inferior		Superior	Inter-mediate	Inferior		Superior	Inter-mediate	Inferior		Superior	Inter-mediate	Inferior
Coniferous trees:	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber	Num-ber
Austrian pine	1	1	0	0	1	1	0	0	0	1	1	0	1	0	1	0
Colorado pinyon pine	0				0	0			2	1	1	0	0	0		
Colorado spruce	0				3	0	1	2	8	2	1	5	5	0	2	3
Jack pine	0				0				0				3	0	1	2
Juniper	67	45	17	5	95	79	10	6	15	13	1	1	45	37	6	2
Limber pine	1	0	0	1	1	1	0	0	0							
Lodgepole pine	0				1	0	1	0	0				0			
Ponderosa pine	14	7	1	6	41	26	10	5	30	14	7	9	32	21	8	3
Scotch pine	0				0				1	0	0	1	0			
Deciduous trees:																
American elm	18	7	4	7	17	5	5	7	13	4	3	6	19	3	6	10
American linden	0				1	0	1	0	0				0			
Black locust	15	7	3	5	11	7	2	2	1	1	0	0	0			
Boxelder	13	8	3	2	24	8	9	7	33	6	10	17	30	5	8	17
Catalpa	0				0				0							
Common hackberry	23	8	10	5	31	18	5	8	7	2	1	4	1	0	1	4
Eastern black walnut	2	2	0	0	2	1	0	1	1	0	0	1	1	0	0	1
Green ash	26	7	10	9	41	13	16	12	43	9	11	23	54	7	12	35
Honeylocust	30	22	7	1	47	33	12	2	11	8	1	2	36	23	9	4
Mulberry	25	12	9	4	29	17	10	2	4	2	1	1	6	3	1	2
Poplars	26	4	2	20	32	7	7	21	22	1	1	1	28	0	2	26
Russian-olive	57	28	14	15	57	40	12	5	41	21	12	8	100	24	11	14
Siberian elm	104	83	17	4	142	129	11	2	51	39	7	5	49	81	11	8
Treofheaven ailanthus	1	0	0	1	0				0				0	0		
Willows	1	0	0	1	1	0	0	1	4	1	1	2	1	0	0	1



Deciduous shrubs:												
American plum	19	14	4	1	19	15	1	3	5	2	1	24
Bessey cherry	3	1	1	1	0	1	0	0	2	1	1	2
Buckthorn	1	0	1	0	1	13	6	1	12	8	1	16
Common chokecherry	8	5	2	1	20	0	0	0	0	0	0	0
Crabapple	1	0	0	1	0	1	1	0	1	0	1	0
Currant	1	0	0	1	2	1	1	0	0	0	0	0
Dogwood	1	0	0	1	0	0	0	0	0	0	0	0
Hawthorn	1	1	0	0	1	0	0	1	0	0	0	0
Honeysuckle	0	1	0	0	2	2	0	0	0	0	1	0
Indigobush amorpha	3	1	2	0	1	1	0	0	0	0	1	1
Japanese rose	3	2	1	0	4	2	2	0	0	0	2	2
Lilac	6	4	1	1	0	1	0	0	0	0	4	6
Manchu cherry	5	4	1	0	1	1	0	0	1	0	1	2
Osage-orange	0	0	1	0	0	1	0	0	0	0	0	0
Siberian apricot	16	5	5	6	2	0	0	2	1	0	0	0
Siberian peashrub	3	0	1	2	37	34	2	1	44	34	4	37
Silver buffaloberry	0	0	0	0	4	0	0	0	4	1	1	2
Skunkbush sumac	21	14	4	3	11	1	0	0	4	4	0	9
Tamarisk	0	0	0	0	0	10	0	1	1	1	0	4
Tatarian maple	0	0	0	0	2	1	1	0	1	0	1	0
Vanhoutte spirea	0	0	0	0	0	1	1	0	0	0	0	0

<sup>1</sup> Ratings are according to the ability of the species to provide shelter from elements.

<sup>2</sup> Scientific names for species are given under the species discussion in the text.

with survival and growth measurements in evaluating responses of shelterbelt species. Ratings were given without making allowance for cultural treatment, soil, or other unidentified environmental factors. Juniper (*Juniperus* spp.), Ponderosa pine (*Pinus ponderosa* Laws.), honeylocust (*Gleditsia triacanthos* L.), Russian-olive (*Elaeagnus angustifolia* L.), Siberian elm (*Ulmus pumila* L.), American plum (*Prunus americana* Marsh.), common chokecherry (*P. virginiana* L.), and Siberian peashrub (*Caragana arborescens* Lam.) had predominantly superior ratings.

Survival, height, spread, and killback data for 16 of the more promising or widely planted species are given by zones and age groups in table 2. Significant comparisons of percentage survival of trees or shrubs in the different zones can be made only within a species of the same age or between different species at the same age. The trees and shrubs in the shelterbelts included in this report were planted at many different spacing distances that affected the growth and survival responses, particularly after the trees or shrubs were more than 10 years old. Present evidence, which is largely observational, suggests that more space per tree or shrub than is usually given is needed for dryland shelterbelt planting. This should be accomplished by planting the trees or shrubs close together in the row and by making the rows farther apart.

Suggested areas of adaptability for all the promising or widely planted species observed are given in table 3.

## SPECIES DISCUSSION

### Coniferous Trees

Both the eastern redcedar (*Juniperus virginiana* L.) and the Rocky Mountain juniper (*J. scopulorum* Sarg.) were planted in the co-operative shelterbelts. Since they are similar in type and adaptability and not easily distinguishable, both species are combined as juniper in the tables. Juniper is subject to winter burning of foliage, in some seasons in some areas, particularly on small trees that lack the protection of other species to the windward. Percentages of tree establishment with bareroot seedlings were high, and survivals remained high through 17 years of age. Plant growth was good. The trees attain only medium heights, but they are dense and low to the ground. Killback percentages remained consistently low for these species at all the ages that are tabulated.

Ponderosa pine (*Pinus ponderosa* Laws.) grew well and had consistently high survivals in the years after establishment. Growth was steady to 14 years, but it slowed down thereafter except in zone 1. This species was slow to reach an average height of 20 feet. Most killback percentages remained low. The lower branches of ponderosa pine tend to shade out and die when the trees are planted close together. Since establishment losses tend to be high, this species should be planted as container-grown trees to obtain reliable stands.

Twenty-five rows of Colorado spruce (*Picea pungens* Engelm.) were observed in shelterbelt plantings ranging from 2 to 26 years old. Between 20 and 55 percent of the trees survived in one five-row planting and between 0 and 8 percent in another five-row planting. At

two locations heights of 12 to 20 feet were recorded for trees 20 years old or older. Killback percentages were very high for this species under dryland culture.

Austrian pine (*Pinus nigra* Arnold), Colorado pinyon pine (*P. cembroides* var. *edulis* (Engelm.) Voss), jack pine (*P. banksiana* Lamb.), limber pine (*P. flexilis* James), lodgepole pine (*P. contorta* var. *latifolia* Engelm. ex S. Wats.), and Scotch pine (*P. sylvestris* L.) were observed in a few shelterbelt plantings. The Austrian pine, Colorado pinyon pine, and limber pine appear to be worthy of trial in some parts of the area (table 3).

Ratings for all coniferous species observed are given in table 1.

## Deciduous Trees

American elm (*Ulmus americana* L.), a hardy species, grew well to 14 years of age. Its survival dropped rapidly after the first 5 years, and killback percentages were high at all ages. Performance in all four zones was uniform. This species is highly susceptible to infestation by the European elm scale. Because of this and lack of good control measures for the scale, American elm cannot be generally recommended for dryland shelterbelt planting in the area. It is also susceptible to Dutch elm disease, which may spread to the area in future years.

The data on black locust (*Robinia pseudoacacia* L.) are limited. Survival was consistently high at all ages owing largely to its suckering habit. However, the trees observed were about as tall at 5 years as at 20 years because of borer injury. Killback was moderate to heavy in most of the plantings in zones 1 and 2. This species is vigorous and rhizomatous and because of annual borer injury to main stems generally grows as a large shrub rather than in tree form.

Establishment percentages of boxelder (*Acer negundo* L.) were high, but survival dropped rapidly to 26 years of age. Growth figures show that it hardly exceeded 15 feet in height or spread in 26 years in zones 1 and 2. In zones 3 and 4 it failed to attain 10 feet in height or spread in 26 years. Killback percentages were high at all ages. This species often resprouted after killback into a large bushy shrub form.

Common hackberry (*Celtis occidentalis* L.) was not widely planted in the shelterbelts observed, but it seemed to survive and grow best in zones 2 and 3. Killback percentages were moderately high at 20 years of age.

Green ash (*Fraxinus pennsylvanica lanceolata* (Borkh.) Sarg.) maintained high survivals to 14 years of age, but percentages of survivals declined to 26 years. It failed to reach an average height of 20 feet in 26 years; in zones 3 and 4 it was taller in plantings observed at 5 years of age than it was in those at 14 and 26 years. Killback percentages after 5 years were extremely high. In the central Great Plains, green ash becomes universally infested with the ash borer, which kills the main trunk of the tree. It is also subject to leaf injury by late-spring frost.

Honeylocust (*Gleditsia triacanthos* L.) is an open tree of moderate density. It maintains high or good survival through 20 years of age. It grew fast for the first 5 years, but it reached only 20 feet

TABLE 2.—Average survival, growth, and killback of 16 shelterbelt tree and shrub species, by zones, at 5, 14, and 17 to 32 years after planting, in the central Great Plains<sup>1 2</sup>

Group, species, and zone	Rows sampled at age (year) of—			Survival at age (year) of—			Height at age (year) of—			Spread at age (year) of—			Killback at age (year) of—		
	5	14	17-32	5	14	17-32	5	14	17-32	5	14	17-32	5	14	17-32
Coniferous trees:															
Juniper:	Number	Number	Number	Percent	Percent	Percent	Feet	Feet	Feet	Feet	Feet	Feet	Percent	Percent	Percent
1.-----	23	35	39	75	89	378	5.7	10.1	313.9	5.0	9.0	313.2	3.5	10.3	36.7
2.-----	36	19	37	75	81	385	4.0	8.7	311.1	3.7	8.4	311.1	5.6	6.3	37.0
3.-----	10	9	15	58	81	380	3.9	9.7	39.5	3.1	9.4	38.6	8.0	13.0	30
4.-----	3	5	6	65	78	380	3.7	6.6	36.3	3.3	5.6	35.8	0	12.0	30
Ponderosa pine:															
1.-----	8	2	48	90	87	463	4.5	16.5	421.0	3.7	9.0	415.0	8.0	0	410.0
2.-----	7	2	48	51	44	464	3.4	12.0	412.5	2.4	8.0	410.4	2.9	0	45.0
3.-----	13	3	45	53	98	478	3.3	14.0	414.2	2.5	10.7	410.0	15.4	0	416.0
4.-----	7	8	10	54	77	453	3.6	10.1	412.6	2.9	7.3	48.5	25.7	7.5	426.0
Deciduous trees:															
American elm:															
1.-----	6	5	43	68	35	418	6.3	30.0	412.3	5.2	15.0	49.3	30.0	20.0	473.3
2.-----	5	2	44	89	85	429	7.8	13.0	49.5	7.0	8.5	49.0	52.0	40.0	465.0
3.-----	1	2	46	100	37	487	7.0	8.0	416.5	6.0	7.5	412.5	0	80.0	436.7
4.-----	0	0	45	---	---	421	---	---	419.0	---	---	---	---	---	436.0
Black locust:															
1.-----	9	6	40	79	76	---	10.0	11.0	---	8.8	7.2	---	33.3	36.7	---
2.-----	1	6	46	92	87	483	11.0	10.2	416.2	10.0	9.0	410.5	0	10.0	440.0
3.-----	2	0	40	53	---	---	4.0	---	---	4.0	---	---	80.0	---	---
4.-----	0	0	40	---	---	---	---	---	---	---	---	---	---	---	---
Boxelder:															
1.-----	2	5	55	100	80	550	12.0	14.0	517.4	12.0	13.0	517.8	20.0	0	540.0
2.-----	8	5	51	81	53	547	8.4	11.0	515.0	6.7	12.5	510.0	40.0	60.0	560.0
3.-----	2	1	14	97	40	537	7.0	16.0	56.0	8.0	14.0	55.3	60.0	80.0	577.1
4.-----	0	0	520	---	---	541	---	---	58.7	---	---	---	---	---	578.0



Common hack- berry:	9	4	4 1	86	50	4 17	7 8	10 5	4 6 0	5 9	9 5	4 6 0	15 6	45 0	4 80 0
1-----	4	6	4 5	51	78	4 74	5 5	12 3	4 13 2	4 3	11 2	4 9 6	50 0	3 3	4 20 0
2-----	9	3	4 2	66	77	4 44	6 8	12 0	4 8 0	5 2	10 0	4 7 0	28 9	46 7	4 60 0
3-----	1	0	4 3	51	-----	4 2	3 0	-----	4 2 0	3 0	-----	4 1 7	20 0	-----	4 93 3
Green ash:															
1-----	9	8	5 10	92	68	5 42	9 7	11 1	5 15 8	6 1	9 1	5 12 9	8 9	52 5	5 44 0
2-----	6	8	5 4	74	77	5 34	8 2	10 5	5 18 0	5 3	9 0	5 10 5	3 3	32 5	5 80 0
3-----	2	3	5 27	100	78	5 30	9 0	8 3	5 7 5	8 0	7 3	5 5 9	0	80 0	5 80 0
4-----	4	2	5 41	86	98	5 50	10 3	6 0	5 8 4	5 5	4 5	5 5 8	10 0	40 0	5 67 3
Honeylocust:															
1-----	12	2	4 6	91	100	4 68	13 0	17 0	4 20 3	11 0	15 0	4 16 5	8 3	10 0	4 16 7
2-----	12	4	4 16	80	91	4 76	12 2	16 0	4 20 1	9 6	13 0	4 16 5	8 3	25 0	4 40 0
3-----	3	1	4 16	65	100	4 69	8 3	18 0	4 17 0	7 0	10 0	4 13 1	33 3	20 0	4 32 5
4-----	0	0	4 9	-----	-----	4 42	-----	-----	4 8 3	-----	-----	4 5 9	-----	-----	4 64 4
Mulberry:															
1-----	10	5	4 3	88	33	4 53	8 8	7 4	4 11 3	8 3	5 6	4 12 7	8 0	72 0	4 53 3
2-----	6	5	4 6	87	69	4 45	8 3	9 2	4 9 5	8 0	11 4	4 11 3	6 7	44 0	4 46 7
3-----	2	0	4 1	87	-----	4 67	4 5	-----	4 7 0	4 5	-----	4 7 0	0	-----	4 20 0
4-----	1	0	4 2	94	-----	4 23	9 0	-----	4 5 5	9 0	-----	4 6 5	0	-----	4 30 0
Poplars:															
1-----	7	11	6 4	65	53	6 0	15 4	24 5	-----	10 7	15 5	-----	22 9	65 5	6 100 0
2-----	11	1	6 5	69	40	6 0	14 5	25 0	-----	11 0	18 0	-----	10 9	80 0	6 100 0
3-----	5	0	6 5	70	-----	6 0	7 8	-----	-----	7 4	-----	-----	72 0	-----	6 100 0
4-----	1	0	6 4	70	-----	6 11	9 0	-----	6 12 5	7 0	-----	6 7 5	20 0	-----	6 90 0
Russian-olive:															
1-----	18	21	7 1	79	73	7 3	7 9	12 1	7 15 0	7 9	11 7	7 12 0	18 9	47 6	7 40 0
2-----	21	8	7 4	82	72	7 26	8 7	14 4	7 11 8	8 7	15 1	7 12 5	7 6	22 5	7 50 0
3-----	22	4	7 10	75	59	7 40	7 6	15 5	7 12 9	7 2	12 5	7 11 8	17 3	30 0	7 64 0
4-----	7	8	7 11	81	72	7 60	8 3	7 6	7 13 9	7 9	7 0	7 12 2	17 1	40 0	7 40 0
Siberian elm:															
1-----	58	37	4 22	88	79	4 65	13 8	21 1	4 25 0	11 2	15 2	4 19 3	10 3	25 4	4 24 5
2-----	70	77	4 41	89	87	4 67	13 3	22 0	4 24 0	10 9	18 0	4 18 6	3 1	17 4	4 20 5
3-----	56	23	4 31	77	92	4 78	12 0	20 7	4 24 1	9 9	16 4	4 19 1	6 1	12 2	4 27 1
4-----	6	9	4 25	96	90	4 55	10 8	22 7	4 18 8	8 3	16 4	4 14 2	3 3	16 7	4 32 0

See footnotes at end of table.

TABLE 2.—Average survival, growth, and killback of 16 shelterbelt tree and shrub species, by zones, at 5, 14, and 17 to 32 years after planting, in the central Great Plains <sup>1 2</sup>—Continued

Group, species, and zone	Rows sampled at age (year) of—			Survival at age (year) of—			Height at age (year) of—			Spread at age (year) of—			Killback at age (year) of—		
	5	14	17-32	5	14	17-32	5	14	17-32	5	14	17-32	5	14	17-32
Deciduous shrubs:															
American plum:	Number	Number	Number	Percent	Percent	Percent	Feet	Feet	Feet	Feet	Feet	Feet	Percent	Percent	Percent
1-----	7	1	3 0	86	100	---	5.1	6.0	---	4.7	6.0	---	5.7	0	---
2-----	5	1	3 5	90	100	---	4.8	7.0	3 5.2	4.4	6.0	3 5.0	12.0	20.0	3 32.0
3-----	10	1	3 11	65	50	3 72	4.8	6.0	3 5.5	4.9	6.0	3 5.4	28.0	60.0	3 30.8
4-----	3	0	3 0	76	---	---	4.7	---	---	5.0	---	---	6.7	---	---
Common choke-															
cherry:															
1-----	0	3	3 2	---	33	3 65	---	1.7	3 5.0	---	---	3 5.0	---	66.7	3 30.0
2-----	1	5	3 7	45	69	3 76	5.0	6.4	3 8.6	5.0	8.6	3 9.7	60.0	28.0	3 20.0
3-----	2	3	3 6	77	93	3 65	6.5	8.3	3 6.5	5.0	8.3	3 8.2	0	6.7	3 23.3
4-----	1	7	3 1	30	83	3 50	5.0	5.1	3 8.0	5.0	6.0	3 9.0	80.0	25.7	3 60.0
Siberian pea-															
shrub:															
1-----	3	2	5 6	67	25	5 52	4.7	5.0	5 7.0	3.0	5.5	5 7.8	13.3	60.0	5 33.3
2-----	1	8	5 2	85	63	5 75	6.0	7.7	5 12.0	5.0	8.6	5 13.0	0	17.5	5 20.0
3-----	5	2	5 13	49	87	5 36	6.0	5.0	5 6.3	5.2	5.5	5 6.6	32.0	30.0	5 61.5
4-----	5	1	5 21	86	21	5 54	5.6	4.0	5 8.2	5.4	3.0	5 8.4	0	20.0	5 34.3
Tamarisk:															
1-----	10	2	4 1	87	45	4 88	7.9	5.0	4 9.0	8.3	3.5	4 10.0	14.0	70.0	4 0
2-----	5	4	4 0	87	90	---	5.6	7.3	---	8.6	10.8	---	4.0	15.0	---
3-----	1	1	4 1	11	0	4 45	8.0	0	4 6.0	6.0	---	4 6.0	40.0	100.0	4 60.0
4-----	0	0	4 0	---	---	---	---	---	---	---	---	---	---	---	---

<sup>1</sup> Averages are for the number of rows shown; all are based on the same rows of trees or shrubs within a zone and age group.

<sup>2</sup> Data were compiled in a short time from shelterbelts of different ages rather than by successive observations of the same rows of trees or shrubs at the age indicated.

<sup>3</sup> 17-year data.

<sup>5</sup> 26-year data.

<sup>6</sup> 32-year data.

<sup>7</sup> 23-year data.

TABLE 3.—*Suggested adaptability of shelterbelt species in dryland plantings in the central Great Plains area*

[x, recommended; o, recommended for trial; —, not recommended]

Group and species	Adaptability in—							
	Northern half of zone—				Southern half of zone—			
	1	2	3	4	1	2	3	4
Coniferous trees:								
Austrian pine.....	—	—	—	—	o	o	—	—
Colorado pinyon pine.....	—	—	—	—	—	—	o	o
Colorado spruce.....	—	—	—	—	—	—	—	—
Juniper.....	x	x	x	x	x	x	x	x
Limber pine.....	—	—	—	o	—	—	—	o
Ponderosa pine.....	x	x	x	x	x	x	x	x
Deciduous trees:								
American elm.....	—	—	—	—	—	—	—	—
Black locust.....	—	—	—	—	o	o	—	—
Boxelder.....	x	x	—	—	—	—	—	—
Common hackberry.....	—	x	x	—	x	x	x	x
Eastern black walnut.....	—	—	—	—	o	o	—	—
Green ash.....	—	—	—	—	—	—	—	—
Honeylocust.....	x	x	x	x	x	x	x	x
Mulberry.....	—	—	—	—	o	o	—	—
Poplars.....	—	—	—	—	—	—	—	—
Russian-olive.....	x	x	x	x	x	x	x	x
Siberian elm (Chinese).....	x	x	x	x	x	x	x	x
Deciduous shrubs:								
American plum.....	x	x	x	x	x	x	x	x
Common chokecherry.....	x	x	x	x	x	x	x	x
Honeysuckle.....	o	o	o	o	o	o	o	o
Lilac.....	o	o	o	o	o	o	o	o
Manchu cherry.....	o	o	o	o	o	o	o	o
Osage-orange.....	—	—	—	—	o	o	—	—
Siberian peashrub.....	x	x	x	x	—	—	o	o
Skunkbush sumac.....	o	o	o	o	o	o	o	o
Tamarisk.....	—	—	—	—	x	x	—	—

in height in 20 years. Killback percentages were not excessively high. It is an ornamental tree with lacy, compound leaves and fragrant flowers; it has long, brown seed pods in the fall. It is subject to injury by borers.

Mulberry (*Morus* spp.) data were limited. Establishment percentages were high, but survival dropped rapidly after 5 years. Maximum height of about 10 feet was reached in very young trees. Killback percentages were high after 5 years. It grew in a bushy shrub form in all but the southeastern parts of the area, where it maintained the tree form.

All species of poplars (*Populus* spp.) growing in the shelterbelts were combined in this report. Survival of poplars, except in very favorable moisture locations, was very low after 5 years. Growth was rapid for a few years, but nearly all trees died by 10 or 15 years of age in dryland plantings.

Russian-olive (*Elaeagnus angustifolia* L.) survived well through 14 years of age, but survival dropped moderately to 23 years. Height seldom exceeded 15 feet, which was sometimes reached in 14 years. Killback percentages were light to moderate. Russian-olive branches are brittle and often the tops of trees kill out. However, dead branches are generally quickly replaced by new shoots, which gives this species a large, bushy shrub form at times.

Siberian elm (*Ulmus pumila* L.) maintained high survival through 14 years, with a moderate loss from then to 20 years. It grew rapidly and was over 20 feet tall at 14 years of age. Killback percentages were low to moderate. This species is vigorous and competitive so that it often suppresses slow-growing species planted too close to it. It is the one species now available that will give dense quick height to a shelterbelt under dryland culture.

Other deciduous tree species in some of the shelterbelts inspected in the area were: American linden (*Tilia americana* L.), catalpa (*Catalpa* spp.), eastern black walnut (*Juglans nigra* L.), tree-of-heaven ailanthus (*Ailanthus altissima* (Mill.) Swingle), and some species of willow (*Salix* spp.). None of these species have been widely tested for dryland shelterbelt planting in the area; neither do any of them show promise for that purpose (table 1).

Ratings for all the deciduous trees observed are given in table 1.

## Deciduous Shrubs

Data for the American plum (*Prunus americana* Marsh.) were limited. Its survival was high and was aided by its rhizomatous habit. Near maximum height was reached by 5 years of age. Killback was light to moderate.

Common chokecherry (*Prunus virginiana* L.) data were limited. Its survival was generally high and was aided by its rhizomatous habit. Growth was rapid and killback was generally light. It maintained a wide, thick row of plants. It is, however, highly susceptible to at least one stone-fruit virus and perhaps to others.

The Siberian peashrub (*Caragana arborescens* Lam.) had some establishment losses, but its survival was excellent thereafter. Near maximum growth was reached by 14 years of age. Killback was moderate. Grasshoppers often defoliated this species; yet it grew again the following year without apparent injury. This species grows better in the northern than in the southern part of the area; its southern limit of adaptability is at about the latitude of the Kansas-Nebraska State line.

Tamarisk (*Tamarix* spp.) data were limited. Survival was generally good, and near maximum height was reached by 5 years of age. Killback percentages were moderate and rather constant. It has lacy, feathery foliage. It is perhaps most adaptable to the south and east of the Siberian peashrub range.

Other shrub species found growing in the shelterbelts of the area that afforded too little data for comparison were: Bessey cherry (*Prunus besseyi* Bailey), buckthorn (*Rhamnus* spp.), crabapple (*Malus* spp.), currant (*Ribes* spp.), dogwood (*Cornus* spp.), hawthorn (*Crataegus* spp.), honeysuckle (*Lonicera* spp.), indigobush amorphia (*Amorpha fruticosa* L.), multiflora rose (*Rosa multiflora* Thunb.), lilac (*Syringa* spp.), Manchu cherry (*Prunus tomentosa*



Thunb.), Osage-orange (*Maclura pomifera* (Raf.) Schneid.), Siberian apricot (*Prunus sibirica* L.), silver buffaloberry (*Shepherdia argentea* (Pursh) Nutt.), skunkbush sumac (*Rhus trilobata* Nutt. ex T. & G.), Tatarian maple (*Acer tataricum* L.), and vanhoutte spirea (*Spiraea x vanhouttei* (Briot) Zab.).

Ratings for the rows that were inspected for each of the deciduous shrub species are given in table 1.

## SUMMARY AND CONCLUSIONS

This publication is a report on the response of certain shelterbelt tree and shrub species to dryland culture in the central Great Plains. This area covers approximately 150,000 square miles. Data were obtained on 482 representative shelterbelts from 1954 through 1956; some of these were located in each of the 79 counties of the area.

The sample shelterbelts received many variations of acceptable cultural treatments, and a variety of different spacing distances were used.

Statistical results showed that greater differences in species response existed among altitude zones than among longitude or geographic zones. Therefore, the data are presented by altitude zones.

All tree and shrub species were rated according to their ability to provide shelter from the elements. Ratings were given without making allowance for differences in cultural treatments. Juniper, Ponderosa pine, honeylocust, Russian-olive, Siberian elm, American plum, common chokecherry, and Siberian peashrub had predominantly superior ratings.

Survival, height, spread, and killback data for 16 of the more promising or widely planted species are given by zones and age groups. Observational evidence indicated that more space per plant than is usually given is needed for dryland shelterbelt planting.

Species that survived and grew well are recommended for trial planting in the area.

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